ECEN 150 Lab 6 – Nodal analysis

Name:

Purposes: (46 points total)

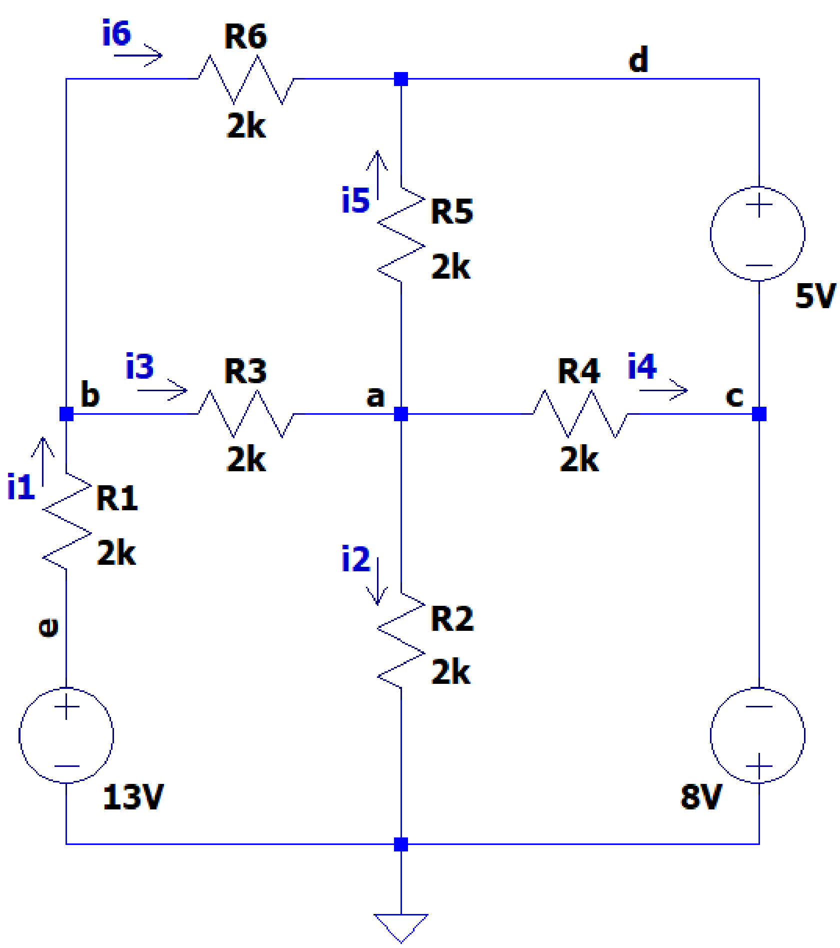
- Practice nodal analysis calculations
- Experimentally confirm the validity of the nodal analysis approach
- Improve breadboarding skills

Procedure:

Part 1. Calculate and measure effective resistances

Step 1: Use nodal analysis to calculate all node voltages.

- Calculate all node voltages for the circuit below. **Either upload a photo of your work into the box, or type your work in the box.**
  - *Hint: Calculate Vc, Vd, Ve before analyzing. Va and Vb are the unknowns.
  - *Hint: because all resistors are the same value, you can multiply both sides of your equations by that resistance to cancel the resistor in the denominator and simplify the denominator.



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(Show your nodal analysis work here, either as a photo or typed) (10 points for showing correct work)

$V_c = -8V$, $V_d = -8V + 5V = -3V = V_d$, $V_e = 13V$

Node a:

$i_3 = i_5 + i_4 + i_2$

$$(2k\Omega)\left(\frac{V_b - V_a}{2k\Omega}\right) = \left(\frac{V_a - (-3V)}{2k\Omega} + \frac{V_a - (-8V)}{2k\Omega} + \frac{V_a}{2k\Omega}\right)(2k\Omega)$$

$$V_b - V_a = V_a + 3V + V_a + 8V + V_a$$

$$-3V - 8V = 4V_a - V_b$$

$$4V_a - V_b = -11V$$

Node b:

$i_1 = i_3 + i_6$

$$2k\Omega\left(\frac{13V - V_b}{2k\Omega}\right) = \left(\frac{V_b - V_a}{2k\Omega} + \frac{V_b - (-3V)}{2k\Omega}\right)(2k\Omega)$$

$$13V - V_b = V_b - V_a + V_b + 3V$$

$$13V - 3V = -V_a + 3V_b$$

$$-V_a + 3V_b = 10V$$

$$\left[\begin{array}{cc|c} 4 & -1 & -11 \\ -1 & 3 & 10 \end{array}\right] \sim \left[\begin{array}{cc|c} 1 & 0 & -\frac{23}{11} \\ 0 & 1 & \frac{29}{11} \end{array}\right]$$

$$V_a = -\frac{23}{11} = -2.09V = V_a$$

$$V_b = \frac{29}{11} = 2.64V = V_b$$

Step 2: Enter your calculated values in the table below. (10 points; 5 calculated + 5 measured)

Node	**Calculated (V)**	**Measured (V)**
Va	-2.09V	-2.049V
Vb (*should be ≈ 2.6 V)	2.64V	2.689V
Vc	-8V	-7.98V
Vd	-3V	-2.96V
Ve	13V	13V

Part 2. Construct & measure the circuit

Step 1: Construct the circuit from page 1

- Obtain six 2 kΩ resistors. *It's a good idea double check that they are in fact all 2 kΩ!
- Construct the circuit from page 1 using a breadboard. **Tips:**
    - *You don't need any wires at all!* If you decide to use wires, do so sparingly.
    - Lay out the circuit on the breadboard so that it matches the layout of the schematic. Example: R2,3,4,5 should form a "+".

- Use banana-to-clip cables to connect the power supplies to the circuit. You can clip directly to the resistors

Step 2: Measure the node voltages.

- Use a voltmeter to **measure all node voltages**. Use the point probes (see the photo) to touch the relevant circuit points.
  - *Don't try poking those into the breadboard holes; it won't make proper contact.
  - You may need to remove the "plugs", as shown in the photo.
- **Enter the measured values in the table on the previous page.** They should be close to the calculated values.

Step 3: Calculate the currents.

- Using your measured node voltages, the "ideal" value of the resistors (2 kΩ), and the current directions indicated in the schematic on Page 1, **calculate** each of the currents.
  - **Enter your results** in the table below, following the format shown in the example.
  - Indicate whether current does in fact flow in the direction we "guessed" as indicated in the schematic of Page 1.

(12 points; 2 per current)

Current	**Symbolic V/R expression** (Assuming current direction indicated in the schematic)	**Numeric V/R expression** (Using measured voltage values from the table)	**Calculated current**	**Current direction** Does current flow in the direction indicated in the schematic?
Example: ix	*(Vx-Vy) / Rx*	*(2V – 3V) / 100 Ω*	*-10 mA*	*No*
i1	(Ve – Vb) / R1	(13V – 2.689V) / 2kΩ	5.16mA	Yes
i2	Va / R2	-2.049 / 2kΩ	-1mA	No
i3	(Vb – Va) / R3	(2.689V +2.049V) / 2kΩ	2.34mA	Yes
i4	(Va - Vc) / R4	(-2.049 + 7.89) / 2kΩ	2.92mA	Yes
i5	(Va – Vd) / R5	(-2.049 + 2.96) / 2kΩ	0.456mA	Yes
i6	(Vb -Vd) / R6	(2.689 + 2.96) / 2kΩ	2.83mA	Yes

Step 4: Show that KCL is satisfied.

- KCL is crucial to the nodal analysis approach used above! Let's make sure KCL is valid.
- Write the KCL equation for nodes Va and Vb. Use the calculated currents from the table above to show that KCL is satisfied.
  - ***Example: KCL at Vx:***
    - **Symbolic ($i_{in} - i_{out} = 0$)**: *ix + iy - iz = 0.*
    - **Numeric**: *1 mA + 2 mA - 3 mA = 0*.
  - **KCL at Va**: (2 points)
    - **Symbolic ($i_{in} - i_{out} = 0$)**: i3 – i5 – i4 – i2 = 0
    - **Numeric (using values from the table)**:
      - 2.34mA - 0.456mA – 2.92mA + 1mA = 0mA
  - **KCL at Vb**: (2 points)
    - **Symbolic ($i_{in} - i_{out} = 0$)**: i1 – i3 – i6 = 0
    - **Numeric (using values from the table)**: 5.16mA – 2.83mA – 2.34mA = 0mA

*****To pass off your circuit, demo it to the TA or instructor and take Lab 6: Quiz 1*****

Part 5. Conclusions statement.

Write a brief conclusions statement that discusses all of the original purposes of the lab. Please use complete sentences and correct grammar to express your thoughts on how you fulfilled the purposes of the lab:

Purposes (repeated):

- Practice nodal analysis calculations
- Experimentally confirm the validity of the nodal analysis approach
- Improve breadboarding skills

Conclusions (10 points):
We practiced nodal analysis calculations by determining all the known voltages and then solving a system of linear equations for the unknown voltages in terms of the KCL equation at each node. Then to test that our calculations were correct and that the nodal analysis approach works, we built the physical circuit and measured the values. They were within measuring error so it proved the approach works and that our calculations were correct. To build the circuit definitely made us practice and improve our breadboarding skills because we had to translate the diagram to a physical circuit and we didn't even use a bunch of messy wires which will help in making less messy breadboards in the future.

Congratulations, you have completed Lab!
You may now submit this document.